Improvements and considerations related to human-robot interaction in the design of a new version of the robotic head Muecas

Felipe Cid[1], Luis J. Manso[2] and Pedro Núñez[2]

***Abstract*— In this article the different decision-making that were followed in the design of the expressive robotic head Muecas are explained. Muecas is a system with a human-caricatured shape, equipped with a pair of robotic eyes, eyebrows, neck and mouth. The main goal in the design was to provide the robot with basic skills for an affective human-robot interaction, where the emphaty and attention plays an important factor. When developing this robotic head, it was necessary to study a number of parameters and characteristics related to human anatomy and psychology, as well as other similar robotic heads or the opinions of experts. All the results of these study are pointed out in this paper. Throughout this work, the step followed in the design in conjuction with the main conclusions drawn from it, are explained. We want that our work helps researchers in this field in their decision making.**

I. INTRODUCTION

The development of robotic platforms with anthropomorphic forms is an area of interest within the social robotics during recent decades. This is due to the rise of the algorithms based on the recognition of emotions, objects and manipulation algorithms based on robotic hands. Within this topic, the use of natural language in robotics is presented as a basis for improving the interaction with the people. Being the primary motivation for the development of systems capable of recognizing and imitating not only the emotions, but also the behavior. Therefore, it is necessary an evolution of the current systems and robots, to remain in the field of human robot interaction.

The current robotic heads are presented as platforms developed directly for the acquisition of information from the environment or objects, by means of systems that use movement or actions similar to the human. However, these heads tend to possess physiological characteristics similar to the human, which allows them to improve the interaction by means of multiple modalities of communication based on natural language. In the social robots, these physiological characteristics related to the anthropomorphism [1], allow the development of systems of recognition and imitation based on different modalities of communication, such as: facial expressions, speech and body language. Therefore, these modalities are a constant source of information on the emotions and intentions of the users in the communication, either through methods that acquire characteristics from a mesh model that analyzes the facial deformations [2], the changes in the prosody of the voice [3] or a model that tracks changes in the skeleton of the user [4].

The main contribution of this work is related to an extension of the publication that describes in detail the robotic head Muecas in [3]. This extension has as objective to describe the changes that are being carried out to develop a second version of the robotic head that consider aspects of different areas of the sciences, such as: psychology, mechanics, robotics, the morphology and the anthropomorphism. Despite the importance of functionality or external appearance of the robot, there are other theories that support the design of robots based on the different processes of learning [5] or action that will be a platform. These designs have as objective to improve the exchange of information [6], empathy with the user [7], and increase the number of possible actions with certain elements of the environment.

This paper is organized as follows: After discussing previous works in the literature related to design of robotic heads., in Section II. In the Section III, presents an overview of the improvements and considerations to take into account in the robotic head Muecas. Next, Section IV described the new mobile elements, degrees of freedom and facial expressions. In Section V, the multimodal systems are described, and finally, Section VI summarizes the conclusions and future works of the approach.

II. RELATED WORKS

The design of robots with human characteristics, so that they can communicate by means of natural language interaction is an area in constant progress. Currently the development of robotic heads is based on the interaction of different modality, whether facial expressions, voice or visual messages or body language. However, the most well-known cases at the level of research are: iCub [8], kismet [9], ROMAN[10][11], KHH [12], WE-4RII [13], SAYA [14][15], Barthoc [16], among others.

In the development of robotic heads there are several works that describe the changes and improvements to older versions of a prototype or product. Examples of this are the robotic heads: Flobi [17], Barthoc, ROMAN, SAYA, among others. Where, ROMAN and Barthoc describe step by step evolution to achieve a similar appearance to the human, while, Flobi describes in detail the development of this platform to get an appearance caricatured and anthropomorphic.

In the design of the different platforms used for the interaction it is possible to analyze four different types of

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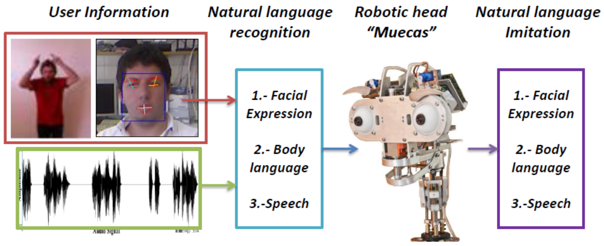
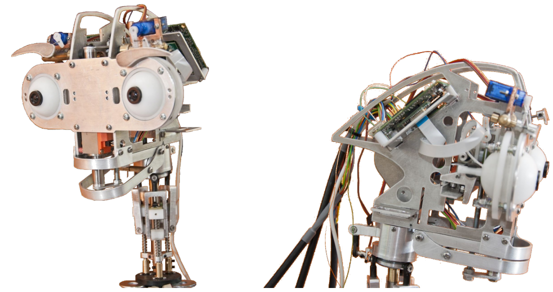


Fig. 1. Overview of the system of recognition and imitation of natural language by the robotic head Muecas.



(a) (b)

Fig. 2. Different perspectives of the robotic head Muecas

appearances, such as: Anthropomorphic, Zoomorphic, caricatured and Functional. Among these types of appearance, there are some that are designed to avoid the Uncanny Valley [18], creating another type of relations. For example, the Zoomorphic focuses on the natural relationship between an animal and a human. Meanwhile, the anthropomorphic appearances are looking for an advanced understanding by means of natural language. In the case of the robotic head Muecas was designed with a caricatured and anthropomorphic concept to support the interaction with young people, but keeping a bit of functional appearance. Finally, Table I shows a comparison of the different existing robotic heads and the head Muecas.

III. SYSTEM OVERVIEW

In this section, the design of a new version of the robotic head Muecas, is presented. The original version of this robotic head was published in [3], therefore, this work will be limited to explain some new improvements and considerations in order to improve the existing platform.

Muecas is a robotic head designed to study new methods of human-robot interaction based on natural language, through different modalities of communication, such as facial expressions, speech, body language, among others. For this reason, this platform uses multiple systems of recognition and imitation of natural language (See Figure 1), that take advantage of the 12 degrees of freedom to imitate the movement of the head in a similar manner to human, through elements such as: neck (four), mouth (one), eyes (three) and eyebrows (four). Besides, a series of sensors are used to acquire a large amount of visual, auditory, and depth information, being this information necessary for the systems of recognition and imitation. Figure 2 shows the robotic head Muecas from different perspectives.

The main aspects to consider in this new version would be associated with incorporation of new degrees of freedom through new mobile elements and the modification of existing ones. The most important changes are related to the elements, such as the eyelids, one degree more of freedom in the neck, new facial expressions and new covers to change the external appearance of the robot. The implementation of these changes, aims to improve the human-robot interaction through new movements and a change in the external appearance of the platform, but maintaining the anthropomorphic and caricatured concept which defines this robotic head.

Then it will describe describe the major consideration in the design, which hope to improve much interaction with users. Also, the technical considerations that will provide to the robotic head Muecas, qualities to represent a movement similar to a human.

- One of the first considerations would be the incorporation of new elements and degrees of freedom to the robotic head Muecas, in order to represent a body movement and behavior more similar to that of human beings by part of the robot.
- The implementation of more systems natural language recognition, through new modalities that deliver a better understanding of human communication. Since this robot only analyzes facial expressions and speech (voice and content), as explained in [3].
- The incorporation of learning processes to improve interactions uncontrolled in the implementation of tests, creation of database and algorithms based on Affordances [19].
- One factor to consider in this new design, it is the ability to integrate a localization system, by means of audio, vision, and depth (RGB-D). With this, it is expected that this robotic platform be able to locate the user to follow him with the cameras at all times, of form invariant to the obstacles or problems that may occur.
- The development of new facial expressions, due to the implementation of new mobile elements in the robotic head.
- One aspect to analyze is the integration of this robotic head in a humanoid robot or mobile platform, with emphasis on how it affects the interaction with the user. In addition, take into consideration the fact to take full advantage of the capabilities of the robotic head with respect to the main robot manipulator
- In order to avoid the Uncanny Valley [20], a human-like appearance is maintained, but caricatured by covers with different designs. Meanwhile, maintains a similar movement to humans, but not identical.

In later sections these aspects will be analyzed one by one, explaining the improvements to be made in the current version of Muecas.

Robotic Head	Neck DoF	Eyebrow DoF	Eye DoF	Mouth DOF	FACS	Stereo Vision	Stereo Audio	RGBD Sensor	Inertial Sensor	Apperance
WE-4RII	4	8	3	5	yes	yes	yes	no	yes	Ant.
ROMAN	4	2	2	1	yes	yes	no	no	yes	Ant.
SAYA	3	no	2	1	yes	no	yes	no	yes	Ant.
KHH	4	no	3	no	no	yes	yes	no	yes	Tech.
BARTHOC	4	2	3	3	yes	yes	no	no	no	Ant.
iCub	3	LED	3	LED	no	yes	yes	no	yes	Ant.
ICAT	2	2	0	5	no	no	yes	no	no	Zoo
Muecas	4	4	3	1	yes	yes	yes	yes	yes	Ant.

TABLE I

COMPARISON OF DIFFERENT ROBOTIC HEADS IN THE LITERATURE (ANT.- ANTHROPOMORPHIC, TECH.- TECHNOMORPHIC , ZOO. - ZOOMORPHIC) (INFORMATION COLLECTED FROM: [3]).

IV. PROBLEMS IN THE CURRENT DESIGN

The old design of Muecas was presented as a platform with anthropomorphic features that was aimed at improving the empathy and naturalness of interactions with different types of users trained and untrained. However, the original design of the head contained many more elements than those described in the above publication [3]. An example of these missing elements are the same eyelids, given that Muecas has a oriented architecture for imitation of facial expressions, the absence of this mobile component is presented as an important gap. In this way, the eyelids are an important source of information related to the emotions of users in a interaction (mainly associated with the intensity of emotions) that allows us to integrate new facial expressions or emotional states, as described in the works of P. Ekman [21]. For this reason, in order to improve the functionality in different types of interactions, have been gradually integrated different aspects that were not incorporated or raised in the design, such as: mobile elements, multimodal recognition systems, new facial expressions, appearance, among others.

The changes in this new version considered some features that other similar robots possessed and some little analyzed trends in the current robotic. On the one hand, were designed new degrees of freedom associated with the neck and the eyelids, which allow to deliver more information through body language. The latter being an important factor, since the eyelids delivered much of the information related to the intensity of facial expressions. On the other hand, within the current robotic heads there are very few that are based on works from psychological studies, to support the possible facial expressions or the basic emotions that should generate a robot with anthropomorphic features. In this same way, we analyzed the possibility of changing the appearance of Muecas, with the objective to promote its appearance caricatured by means of covers. These covers allow the robot, the development of interactions closest and prevent manipulation of the mechanical elements by children.

This paper is divided into subsections that describe different aspects to consider in the design of new types of social anthropomorphic robots (See Figure 3).

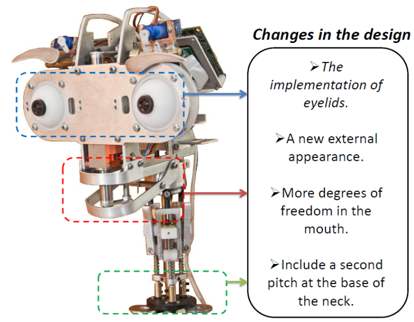


Fig. 3. Future changes in the design

A. Robotic eyelids

The eyelids are a major challenge in presenting a total change in the current structure of the eyes, since they need a minimum of two degrees of freedom to generate new facial expressions (See Figure 13). These degrees of freedom will be implemented through two servomotors HITEC HS-45HB (one in each eye), being the same motors used in the degrees of freedom of the eyebrows. This new movement related to the eyelids needs of a complex system that would allow an individual movement and synchronized movements in each eye, as shown in Figure 4. For this reason, it is developing a system responsible for moving the eyelids, through a mechanism based on folding layers covering the eyeball from the top to the bottom (See Figure 5(a)).

Within the literature, there are many works that demonstrate in practical ways that the eyelids are an essential part in the generation of facial expressions and the transmission of visual information [22][16]. However, in order to produce a greater degree of expressiveness and facial expressions more complex and realistic on the part of Muecas, is required of four degrees of freedom, as shown in Figure 5(b) and 6. These degrees of freedom allow generating a movement that the user perceives as similar to humans, which is necessary for the generation of facial expressions based on FACS [21] that classifies these movements (e.g. AU45 or AU46).

One of the main advantages in the implementation of the eyelids, is the ability to dramatically increase the emotional expressiveness of this platform. Due to that greater facial expressiveness is associated mainly with high levels of exci-

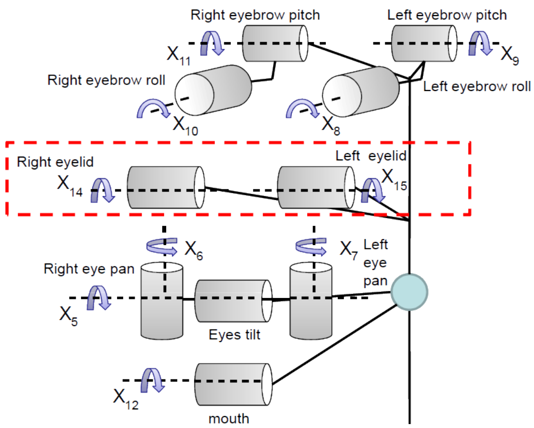
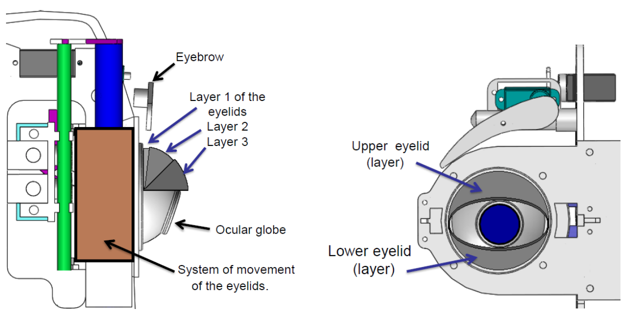


Fig. 4. Image of the degrees of freedom present in the eyelids.



(a) (b)

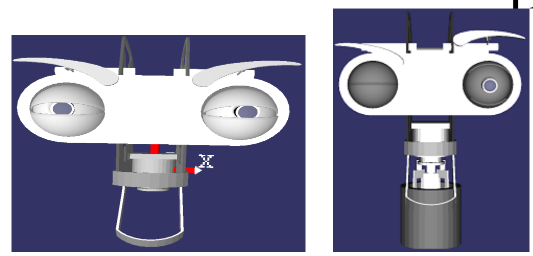
Fig. 5. Design of the system of movement of the eyelids.

tation in the emotions transmitted by the robot. Figure 6(a) shows an example of how the eyelids affect the perception of some facial expressions. Meanwhile, Figure 6(b) shows how the eyelids give the possibility to make some gestures typical of natural language as a simple Wink.

B. neck

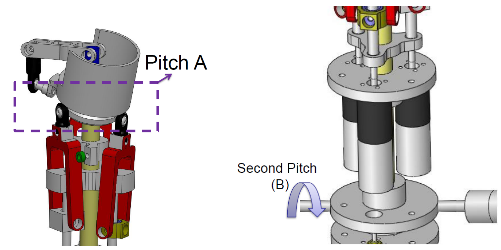
The neck of the robotic head Muecas is one of the more complex parts in the design and implemented these platforms. Since this element represents the key to the imitation of the movements of the human body language, introducing a system that recreates the movement of the human neck in such a way as to be recognizable movements by a user. However, these movement are generated in a different way to humans, which makes it possible to avoid the Uncanny Valley [18]. Because the design of this robot does not expect imitate identically human movements, but generate similar representations which are recognizable by users.

However, after a series of analyzes, it was decided to implement a movement missing on the base, known as a second pitch. This movement is basic in users, and allows a greater angle of inclination for the head that the first pitch. Figure 7(b) shows the implementation of this second Pich in a 3D model of the physical components of the neck, whereas in Figure 7(a) is shown the first pitch. In each of the mobile elements of the neck were used DC-micromotor 1724-024 SR (Encoder IE2-16 with 76:1 gear ratio), even in the new degree of freedom. Figure 8 shows the structure of



(a) (b)

Fig. 6. a) Example of the importance of the eyelids in the expressiveness of emotions of high arousal; and b) Example of a basic gesture of body language.



(a) (b)

Fig. 7. Design of degree of freedom related to the pitch.: a) Pitch A; and c) Pitch B.

the degrees of freedom in the existing robotic head, including the new degree of freedom associated with a second pitch. Finally, some examples of other platforms that implemented this movement, are: ROMAN [10][11], Barthoc [16], among others.

C. mouth

The mouth plays a significant role in how we perceive speech of an announcer in a conversation. This is due to the fact that much of the information, even auditory, requires a feedback through visual information. This is known as the McGurck effect [23]. However, the current design of robotic mouth does not allow a full perception of this effect. Given that this robotic mouth has only one degree of freedom, with the only function of opening and closing the mouth (See Figure 9(a)). For this reason, it has established the design of a robotic mouth that has the minimum capabilities of deformation, either in the opening, the contraction of the contours, and the extension of the lips forward (See Figure 9(b)). However, these movements are in development because they are a challenge to the current physical design.

Finally, it is important to mention that within most of the robotic heads, the incorporation of these mobile elements is not considered necessary, despite its importance in a communication based on auditory information.

D. External appearance

In the design of the robotic head Muecas, external appearance plays a crucial role to perform tasks of emotional interaction with users. For this reason, is not only is intended to catalog the appearance of the robot as anthropomorphic and caricatured, but develop a series of covers that allow experimenting with the human robot interaction.

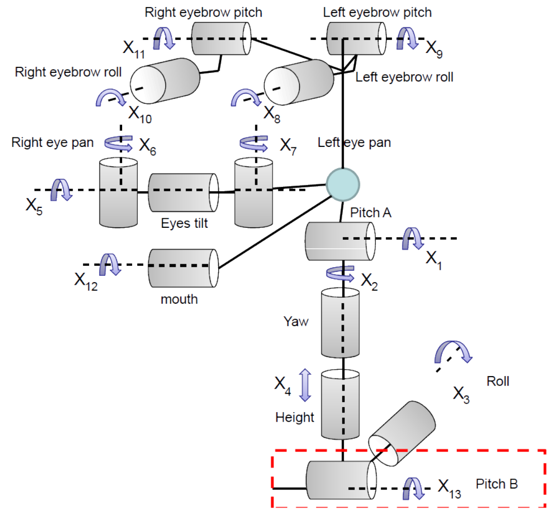
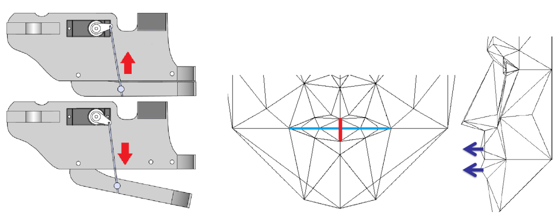
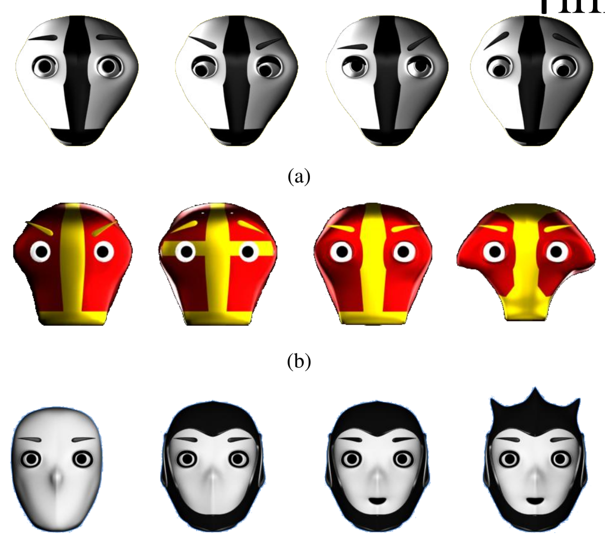


Fig. 8. Image of the degrees of freedom present in the neck, more the degrees of freedom associated to a second pitch in the base of support.



(a) (b)

Fig. 9. a) Current robotic mouth of Muecas with a one degree of freedom; and B) Movements that should be emulated by Muecas, such as: contraction of the lip corners (blue), extension of the lips forward (purple), and the opening of the mouth (red).

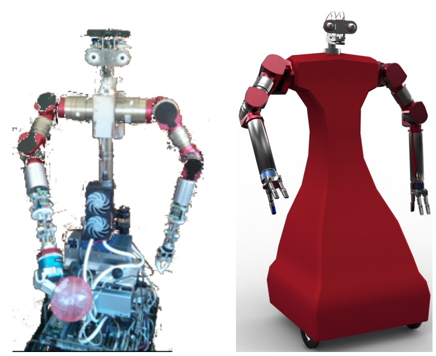


(a)

(b)

(c)

Fig. 10. Different prototypes of the cover for the robotic head Muecas.: a) First prototype of cover; b) Second prototype of cover. and c) Final prototype of cover.



(a) (b)

Fig. 11. a) Current image of the robot Loki.; and b) 3D model of the new cover of the robot Loki. (Image (a) obtained from the publication: [19])

Figure 10 shows the covers designed for the robotic head Muecas through 3D models. The objective of these covers is to improve the level of empathy and care of people, mainly children, and bring them to a higher level of interaction without resorting to too many humanoid forms similar to the human that will lead us to the Uncanny Valley [18].For this reason, the choice of shapes similar to toys or cartoons seek to promote better interaction, as has been demonstrated in multiple works as: Kismet [9], Flobi [17], iCat [24], Probo [25], among others.

Currently, the autonomous robot Loki [26] has integrated the robotic head Muecas, in order to improve the user's response before a robot of large proportions. Figure 11(a) shows the robot Loki, and Figure 11(b) shows the cover ready to Loki. Given that this cover expects to achieve the same result that the prototypes described above, through an increase in the empathy and care in a user interaction with the robot.

E. New sensors and actuators

The original design of the robotic head Muecas possessed 12 degrees of freedom associated with a number of actuators that allow the movement of the neck (Pitch, Roll and Yaw), eyes (pitch and roll), eyebrows (Tilt and Pan), and mouth (aperture). Where is prioritized a natural movement that is identifiable as similar to humans but with a different kinematic. However, the constant interaction of this head with non-trained users and the general public, it allowed us to analyze the opinion of the user with regard to what elements are necessary to improve the current design. Thus, this feedback directed us toward a platform containing more mobile elements such as: eyelids, a second pitch, and more movements in the mouth. For this reason, new degrees of freedom need a series of actuators responsible for carrying out this function. Table II describes the current elements with the degrees of freedom, together to the new actuators and the degrees of freedom that are incorporated into this platform.

In the case of the sensors, this new version of Muecas only incorporates two microphones in the positions of the ears of the robotic head, in order to acquire auditory information for the development of tracking systems for users through the audio. Table III summarizes the current and new devices related to information visual, auditory and depth.

Element	DoF	Motors
Eyes	3	3 motors divided into 2x Faulhaber LM-1247 linear DC-servomotor (Pan) and 1 x Faulhaber LM-2070 lineal DC-servomotor (Tilt).
Eyebrows	4	4 HITEC HS-45HB servomotors
Neck	4+**1**	4+**1** DC-micromotor 1724-024 SR (Encoder IE2-16 with 76:1 gear ratio)
Mouth	1	1 HITEC HS-45HB servomotors.
Eyelids	**2**	**2** HITEC HS-45HB servomotors.

TABLE II

DESCRIPTION OF THE DIFFERENT DEGREES OF FREEDOM AND MOTORS OF THE ELEMENTS OF THE ROBOTIC HEAD MUECAS. (INFORMATION OBTAINED FROM: [3]).

Type	Sensors	Position
Stereo Vision	Two cameras Point Grey Dragonfly2 IEEE-1394	Eyes.
Stereo Audio Input	Two microphones connected to the pre-amplifier M-AUDIO MOBILEPRE USB	Sides of the head (ears).
Stereo Audio Output	Two speakers connected to the pre-amplifier M-AUDIO MOBILEPRE USB	Base of the head.
Inertial Sensor	PhidgetSpatial 1042–0 3/3/3	Back of the head.
RGBD Sensor	Microsoft Kinect Sensor or Xtion PRO LIVE Sensor (optional)	On the head.

TABLE III

DESCRIPTION OF THE DIFFERENT SENSORS OF THE ROBOTIC HEAD MUECAS. (INFORMATION OBTAINED FROM: [3]).

F. New Emotional States

The development of the human-robot interaction is present in the day to day, for this reason it is necessary to extend the capabilities of the current robots, in order to improve the skills of verbal, visual and emotional communication. With this objective, we carried out a study of the state of the art of the different theories about what are the basic emotions in human beings. The results of this study allowed for the selection of three theories of emotions studied and used in the robotics, such: the theory of Ekman [21], Russell [27] and Plutchik [28]. These three theories represent the basis for the choice of the emotional states with what will work the robotic head, which are: happiness, fear, sadness, anger and neutral. Where each emotional state is associated with a facial expression that will be recognized and imitated by the robotic head. Figure 12 shows these five emotional states with their respective facial expressions, which are performed by the user and imitated by Muecas.

In the Table IV shows the correspondence of the emotional states within the theories mentioned above. However, it is important to comment that the state $Neutral$ is a state not associated with any emotion, because it indicates the absence of a predominant emotion. In the same way, the state $Confused$ is presented as an emotional state necessary

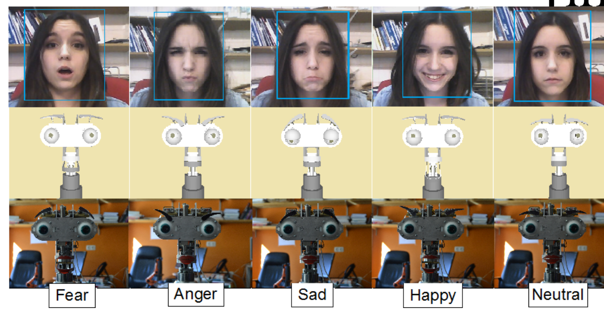
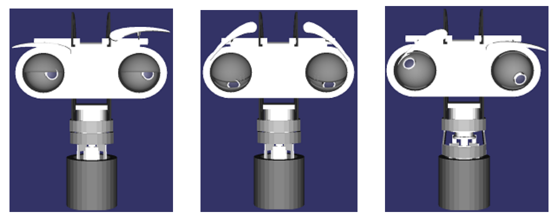


Fig. 12. Facial expressions recognized and imitated by the robotic head Muecas. (Image obtained from the publication [3])



(a) (b) (c)

Fig. 13. New facial expressions: a) Bored; b) Lonely; and c) Confused.

to present an idea or concept to the user, whether the information that delivery is not clear and it causes problems to the robot. With regard to emotional states in Table IV, it is important to mention that the names of some states may vary between emotional theories, for example: $Fear$ is $Afraid$ in the theory of $Russell$.

Emotional State	Ekman [21]	Russell [27]	Plutchik [28]
Sadness	x	x	x
Happiness	x	x	x
Fear	x	x	x
Anger	x	x	x
Neutral	–	–	–
Bored		x	x
Depressed		x	x
Confused	–	–	–

TABLE IV

EMOTIONAL STATES OF THE SYSTEM VS. THEORIES OF BASIC EMOTIONS IN THE FIELD OF PSYCHOLOGY.

These emotional states can be regarded as basic in the theories of the emotions, because they can be found in several works with different points of view, such as: Arnold [29], Frijda [30], Gray [31], Izard [32], James [33], McDougall [34], Oatley [35], Tomkins [36], among others. Where the emotions are classified by the inclusion criteria given by the author, as for example: Ekman considered a small group of universal emotions, Plutchik classifies the emotions with regard to adaptive biological processes, or Tomskins that considers the density of neuronal activity. (the reader can refer to some interesting works in [37]). Finally, Figure 13 shows the new emotional states through the simulator InnerModelSimulator of the framework RoboComp [38].

One aspect to take into consideration, in the case of the robots, is that the artificial facial expressions should be more exaggerated, to avoid any type of emotional confusion or ambiguity in communication. This is due to the fact that communication systems based on natural language have a limited amount of facial expressions, associated with the low number of actuators that generate movements in the elements of the face. In contrast, a human has a large amount of facial muscles that generate distortions studied and classified by systems, such as the FACS [21].

V. MULTIMODAL SYSTEM

The recognition systems of the robotic head Muecas [3], can be divided into two basic systems: Facial expressions and speech. However, in order to improve the system of recognition of emotions, and analyze the most of the information related to natural language, a module capable of analyzing the information of the body language through the depth sensor of Muecas has been integrated. This system analyzes a model of the human skeleton by extracting 7 features related to the movement, which allows to analyze the body language and estimate the emotional state of the user (more details in [4]). The output of this system provides information relating to the AUs for each element of a facial expression in the user. Thus, these AUs that are updated by each expression allow the robot not only recognize, if not also imitate these expressions in real time, in accordance with the relationship between the facial deformities and the movements of the mobile elements of Muecas (See Table V). These elements of the robotic platform include: eyebrows, eyelids, eyes and mouth.

Emotion	AUs	Mobile components of *Muecas*
Neutral	-	-
Happy	AU6-AU12-AU25	Eyebrows-Eyelids-Eyes-Mouth
Sad	AU1-AU4-AU15-AU17	Eyebrows-Eyelids-Eyes
Fear	AU1-AU4-AU20-AU25	Eyebrows-Eyelids-Mouth
Anger	AU4-AU7-AU17-AU23-AU24	Eyebrows-Eyelids

TABLE V
MOVEMENTS OF THE ROBOTIC HEAD *Muecas*, AND MOBILE ELEMENTS ASSOCIATED WITH EACH EMOTIONAL STATE (TABLE OBTAINED FROM THE PUBLICATION: [3]).

In the case of multimodal localization systems, it is working to integrate the tracking system of the model of mesh Candide-3 [2] with a localization system based on audio, as the submitted by [39].

A. Learning by imitation in robotic heads

One of the main attributes of the systems for recognition of emotions associated with this platform, is the property of self-training with the robotic head Muecas.This process uses TTS and ASR systems (explained in [3]), to generate a database of information of learning for a system of recognition of facial expressions based on Candide-3 [2], without the need for a supervisor or a third party during the experiment. Given that the conditions of the experiment are focused on improving the interaction, and that Muecas only has a limited amount of facial expressions associated with different emotional states, the process of imitation will provide of exaggerated facial expressions and specific for each emotion (See Table V) that will be recognized by the user.

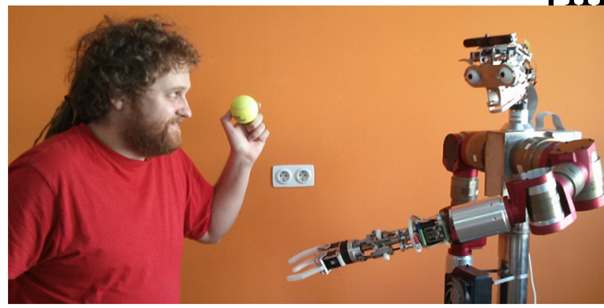


Fig. 14. The user interacts with the robot Loki and the robotic head Muecas

This process of interaction, it is carried out by means of verbal messages, such as:

- Muecas: The test has begun, please express a facial expression.
- User: (The user performs a certain facial expression, trying to show a specific emotion)
- Muecas: (The robot, to recognize the facial expression of the user, imitates the expression through the movement of its mechanical components)
- User: (Evaluates the success/error in the recognition of facial expression)
- Repeat this sequence until complete the experiment.

Finally, this process is repeated for all emotional states required in 20 repetitions.

An example of systems of learning related to robotic head Muecas is [40]. In this case, we used Muecas to perform the interaction with the user, while acquires the emotional information of the user and about the objects in the environment. Given that this information from the user and the objects, are the basis for the use of affordances. Finally, Figure 14 shows an example of a complex interaction that includes facial expressions, and robotic manipulators.

VI. CONCLUSIONS

The robotic heads need a process of development and constant evolution, which will enable them to improve and adapt in a better way to users. Either through non-invasive methods, interactions based on the natural language or forms more user-friendly. Currently, the robotic heads do not incorporate certain fundamentals as psychological theories of the emotions or the effect McGurck that seek to support the compression of the human behavior through the analysis and observation. However, this work uses these theories related to emotions and how the human beings communicate to describe new aspects that are relevant to the design of anthropomorphic robotic heads, oriented to the human-robot interaction. Describing what are the enhancements and considerations that were obtained after working with the first version of Muecas.

In relation to other robotic heads, Muecas can be considered a robot designed for the human-robot interaction and the development of learning by imitation based on natural language. Due to the different types of aspects evaluated in this document, have as goal replicate the movement and emotions in a different way to humans, but that is easily recognizable by the user. On the one hand, this platform focuses on the systems to improve the interaction through behaviors and actions similar to the human based on learning by imitation. On the other hand, the hardware focuses on elements such as the movements of the neck and eyes that allow a user tracking by cameras (within the eyes), avoiding sudden movements or jumps by means of linear motors.

In this paper, one of the main topics that were evaluated was the incorporation of new degrees of freedom in elements, such as: neck, eyelids and mouth. Besides, the integration of tracking systems and a new external appearance based on covers, aim to improve the interaction through communication.

Future work is aimed at implementing the considerations described in this paper, through the integration of an evaluation process based on interaction with non-trained users in uncontrolled environments.

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